

**NATURAL RESOURCES CONSERVATION SERVICE  
CONSERVATION PRACTICE STANDARD**

**IRRIGATION SYSTEM, SPRINKLER**

(No. and Ac.)  
CODE 442

**DEFINITION**

An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

**PURPOSE**

This practice may be applied as part of a conservation management system to achieve one or more of the following:

- Efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment.
- Climate control and/or modification.
- Applying chemicals, nutrients, and/or waste water.
- Leaching for control or reclamation of saline or sodic soils.
- Reduction in particulate matter emissions to improve air quality.

**CONDITIONS WHERE PRACTICE APPLIES**

The sprinkler method of irrigation is suited to most crops, irrigable lands, and climatic conditions where irrigated agriculture is feasible.

Areas must be suitable for irrigation or sprinkler water application and have an adequate supply of suitable quality water available for the intended purpose(s).

Filtering, screening, and/or settling the water, before it enters the system, may be necessary if it contains particulate matter, algae, or other material that could plug the sprinkler nozzles.

This standard applies to the planning and design of water application through sprinkler discharge systems. It pertains to the planning and design of all sprinkler components except for special structures, such as permanent main

and lateral pipelines or pumping plants. Other components shall meet appropriate NRCS Conservation Practice Standards.

This standard does not include criteria for mini- or micro-sprinkler systems. NRCS Conservation Practice Standard 441, Irrigation System, Microirrigation covers these.

**CRITERIA**

**General Criteria for All Purposes**

The criteria for the design of components not addressed in NRCS practice standards shall be consistent with sound engineering principles.

Each sprinkler discharge system must be designed as an integral part of an overall plan of conservation land use and treatment for the intended purpose(s) based on the capabilities of the land and the needs of the operator. Base the selected system on a site evaluation and expected operating conditions. Verify that soils and topography are suitable for the intended purpose(s).

**Water Measurement.** All irrigation systems will have an operational water-measuring device installed as an integral part of the system.

**Capacity.** Design the sprinkler irrigation system with adequate capacity to accomplish the purpose(s) of the system.

**Depth of Application.** Net depth of application shall meet criteria for the intended purpose, not exceed the available soil water holding capacity of the root zone, and meet the land user's management plan for the intended purpose.

**Design Application Rate.** Select rates to minimize runoff, translocation, and unplanned deep percolation. Apply additional conservation measures, such as furrow diking, in-furrow chiseling, conservation tillage, or residue management, as needed and appropriate.

**Distribution Patterns, Nozzle Spacing, and Height.** Select a combination of sprinkler spacing, nozzle size,

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and operating pressure that provides the design application rate and distribution. Consider velocity and direction of prevailing wind.

Use Coefficient of Uniformity (CU) data or distribution uniformity (DU) in selecting sprinkler spacing, nozzle size, and operating pressure. Definitions of each of these uniformity values are in the NRCS National Engineering Handbook, Part 652.0904, Irrigation Guide.

**Management Plan.** Develop an Irrigation Water Management plan that meets NRCS Conservation Practice Standard 449, Irrigation Water Management. When used as part of a Comprehensive Nutrient Management Plan (CNMP), write a waste utilization plan and/or nutrient management plan that meets the requirements of NRCS Conservation Practice Standards 633, Waste Utilization, and 590, Nutrient Management, as appropriate.

**Pipelines.** Design the main lines, submains, and supply lines to insure that required water quantities can be conveyed to all operating lateral lines at required pressures. For detailed criteria, see NRCS Conservation Practice Standard 430, Irrigation Pipeline.

Size all pipelines to ensure that there is an economical balance between the capitalized cost of the pipe and pumping costs. While oversizing of the mainline is initially more expensive, the reduction in friction loss might reduce energy cost, pump size, and overall operating cost, on a long-term basis.

**Pump and Power Unit.** Pump and power units shall be adequate to efficiently operate the sprinkler system at design capacity and pressure. See details in NRCS Conservation Practice Standard 533, Pumping Plant.

### **Additional Criteria for Center Pivot or Linear-Move Sprinkler Systems**

**Design Capacity.** Sprinkler irrigation systems shall have either; (1) capacity adequate to meet peak water demands of all irrigated crops in the design area; or (2) capacity adequate to meet requirements of selected irrigations during critical crop growth periods when planning less than full irrigation. Allow for reasonable water losses in computing capacity requirements.

**Distribution Patterns, Nozzle Spacing, and Height.** Center Pivot (Heermann-Hein) or Linear Move (Christensen) system CU shall not

be less than 85% (DU = 76%), except as noted in criteria for a Low Energy Precision Application (LEPA) system. In lieu of the manufacturer's CU information, use the Center Pivot Evaluation and Design (CPED) model, or similar software. Consider manufacturer's information on nozzle sizing, excluding the end gun and the first 12 percent of pivot length (not to exceed 250 feet), acceptable system CU documentation.

In the absence of CU data, select nozzle size, operating pressure, and wetted diameter, with manufacturer sprinkler performance tables. To the extent possible, low-pressure spray nozzles shall be at uniform heights along the length of the lateral, with the exception of height adjustment to increase wetted diameter for runoff control. From a point midway between the first and second tower to the distal end of a center pivot, spray nozzle spacing along lateral lines shall not exceed 25% of the effective wetted diameter and impact sprinkler spacing shall not exceed 50 percent of the effective wetted diameter, using the manufacturer's data.

Nozzles, typically less than 7 feet from ground surface, that discharge water in the crop canopy for most of the growing season, shall also meet the criteria of a Low Pressure in Canopy (LPIC) system as defined in this standard.

### **Additional Criteria for LEPA and Low Elevation Spray Application (LESA) Center Pivot or Linear-Move Sprinkler Systems**

**Distribution Patterns.** Use nozzle discharge CU (Heermann-Hein weighted area method) on center pivot systems for selecting sprinkler spacing, nozzle size, and operating pressure. CU shall not be less than 94% at the calculated design flow rate. On linear systems, base discharge on equivalent unit areas.

**Nozzle Spacing.** Nozzle spacing shall not be greater than twice the row spacing of the crop, not to exceed 80 inches.

**Surface Storage.** Guidance on soil surface storage design is in the National Engineering Handbook, (NEH), Part 652, Page 6-50.

### **Additional Criteria for LEPA**

**Discharge Height.** Water shall discharge through a drag sock or hose on the ground surface, or through a nozzle equipped with a

bubble shield or pad at a uniform height not to exceed 18 inches.

**Row Arrangement and Storage.** LEPA systems are only applicable on crops planted with furrows or beds. LEPA systems shall have row patterns that match the nozzle movement (e.g., circular for center pivots). Do not apply water in the tower wheel track of a LEPA system. Provide surface storage such as furrow dikes or implanted reservoirs, to eliminate translocation or runoff.

**Slope.** LEPA systems shall not exceed 1.0 percent slope on more than 50 percent of the field.

Systems that utilize bubble pads or shields, or drag hoses for a portion of the crop year and then spray nozzles at uniform height not exceeding 18 inches for a portion of the crop year shall meet LESA criteria.

#### **Specific Additional Criteria for LESA**

**Discharge Height.** LESA systems shall discharge water through a spray nozzle at uniform heights not to exceed 18 inches.

**Row Arrangement and Storage.** LESA systems are applicable on crops flat planted, drilled, or planted with furrows or beds. LESA Systems should provide surface storage such as furrow dikes or implanted reservoirs, or farming practices such as conservation tillage, in-furrow chiseling, and/or residue management to prevent runoff.

**Land Slope.** LESA systems shall not exceed 3.0 percent slope on more than 50 percent of the field.

#### **Additional Criteria for LPIC and Mid Elevation Spray Application (MESA) Center Pivot or Linear-Move Sprinkler Systems**

Systems that utilize bubble pads or shields or drag hoses for a portion of the crop year and spray nozzles for a portion of the crop year and not meeting all of the LESA criteria, shall meet LPIC criteria.

**Distribution Patterns, Nozzle Spacing, and Height.** For row crops, when nozzles operate in canopy for 50 percent or more of the growing season, nozzle spacing shall not exceed every other crop row. Avoid in-canopy heights of high leaf concentration (e.g. Corn near the ear height or approximately four feet). Use local

research and Extension Service information with applicable crops as a guide for establishing appropriate nozzle spacing, height, and row arrangement.

CU (Heermann–Hein for center pivots) shall not be less than 90% for all LPIC and MESA Systems with nozzle heights less than 7 feet.

CU shall not be less than 85% (DU = 76%) for MESA Systems with nozzle heights over seven feet.

**Land Slope.** The slope for LPIC and MESA systems shall not exceed 3.0 percent on more than 50 percent of the field for fine textured soils and not exceed 5 percent on more than 50 percent of the field on coarse textured soils.

#### **Additional Criteria for Fixed Solid-Set, Big Gun, and Periodic Move Sprinkler Systems**

**Design Capacity.** Sprinkler irrigation systems shall have; (1) capacity adequate to meet peak water demands of all crops irrigated in the design area or, (2) capacity adequate to meet requirements of selected water applications during critical crop growth periods when planning less than full irrigation. Allow for reasonable application water losses.

**Design Application Rate.** The design application rate shall be within a range established by the minimum practical application rate under local climatic conditions, and the maximum application rate consistent with soil intake rate, slope, and conservation practices used on the land. If two or more sets of conditions exist in the design area, the lowest maximum application rate for areas of significant size shall apply.

**Lateral Lines.** Design lateral lines so that the pressure at any sprinkler does not vary more than 20 percent of the planned operating pressure or, use pressure regulators or other flow control devices at each outlet. Design flow can vary up to 10%.

**Distribution Patterns and Spacing.** Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and acceptable CU distribution.

If available, use CU or DU data to select nozzle size, operating pressure, and sprinkler spacing. CU shall not be less than the following:

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75 % (DU = 60%) for deep-rooted (4 feet or more) field and forage crops where fertilizers and pesticides are not applied through the system.

85 % (DU = 76%) for high-value or shallow-rooted crops and for any crop where fertilizer or pesticides are applied through the system.

In the absence of CU data, maximum lateral and nozzle spacing shall comply with the following criteria:

1. With low (2-35 psi), moderate (36-50 psi), and medium (51-75 psi), pressure nozzles operating at design pressure, the sprinkler spacing along lateral lines shall not exceed 50 percent of the wetted diameter published by the manufacturer.

The spacing of laterals along the main line shall not exceed 65 percent of the wetted diameter. Use **Table 1** to adjust spacing, if the wind may affect the distribution pattern.

**Table 1**  
**Lateral Spacing**

| Wind Speed (mph)           |        |         |      |
|----------------------------|--------|---------|------|
| 0                          | 1 to 5 | 6 to 10 | > 10 |
| Percent of Wetted Diameter |        |         |      |
| 65%                        | 60%    | 50%     | 45%  |

2. For high-pressure, and big gun sprinklers (>75 psi), the distance between two sprinklers on adjacent lateral lines shall not exceed 65% of the wetted diameter. With average velocity winds of 5 to 10 mph winds, reduce the sprinkler spacing to 50% of wetted diameter and for velocity greater than 10 mph, reduce the spacing to 30%.

Towpath spacing guidance is in **Table 2**.

3. Sprinkler spacing requirements for orchards, including subtropical fruits:

- Triangular pattern. Nozzle spacing along lateral lines shall not exceed 65 percent of the wetted diameter. The lateral spacing along the main line shall not exceed 70 percent of the wetted diameter.
- Square or rectangular pattern. Nozzle spacing along the lateral and the

lateral spacing along the main line shall not exceed 65 percent of the wetted diameter at operating pressure.

- Reduce spacing between sprinklers and lateral lines by 2.5 percent for each mph over 3 mph average wind velocity normally occurring during planned hours of operation.

**Table 2**  
**Towpath Spacing**

| Wind Speed (mph)           |        |         |      |
|----------------------------|--------|---------|------|
| 0                          | 0 to 5 | 5 to 10 | > 10 |
| Percent of Wetted Diameter |        |         |      |
| 80%                        | 70%    | 60%     | 50%  |

**Risers.** Except for under-trees, nozzles shall be high enough to prevent interference with the distribution pattern from the tallest crop. Riser heights shall not be less than shown in **Table 3**.

**Table 3 – Riser Height**

| Sprinkler discharge -gpm | Riser length -inches |
|--------------------------|----------------------|
| Less than 10             | 6                    |
| 10-25                    | 9                    |
| 25-50                    | 12                   |
| 50-120                   | 18                   |
| More than 120            | 36                   |

Risers over three feet in height shall be anchored and stabilized.

### **Additional Criteria for Climate Control and/or Modification**

**Design Capacity.** For temperature control, the sprinkler irrigation system shall have sufficient capacity to satisfy the evaporative demand on a minute-by-minute basis throughout the peak use period.

For frost protection, the system shall be capable of applying the necessary rate, based on the minimum temperature, maximum anticipated wind speed, and relative humidity, in a uniform manner. Ensure the capacity is enough to supply water for protection of the entire crop.

NEH, Part 623, Chapter 2, Irrigation Water Requirements, contains guidance on using

sprinkler irrigation systems for climate control and/or modification.

**Additional Criteria for Chemical, Nutrient and/or Waste Water Application**

The installation and operation of a sprinkler irrigation system for the purpose of chemical or nutrient application (chemigation) shall comply with all federal, state, and local laws, rules, and regulations. This includes backflow and anti-siphon prevention measures. Additionally, surface waters shall also be protected from direct application.

Injectors and other automated equipment shall be located adjacent to the pump and power unit and installed in accordance with state regulations, or lacking the same, in accordance with manufacturer's recommendation. The chemical injection device shall be within 1 percent of maximum injection rates and easily calibrated and adjustable for all chemicals at the required injection rate.

Design sprinkler systems used to apply waste with nozzles large enough prevent clogging.

**Design Application Rate and Timing.** Application rates shall meet the levels specified in General Criteria. Timing of chemical applications shall allow enough time to pressurize the system, deliver the chemicals at rates specified by the label, and flush the lines.

**Coefficient of Uniformity.** If available, use CU or DU data in selecting sprinkler spacing, nozzle size, and operating pressure. The CU shall not be less than 70% for wastewater application and not less than 85% (DU = 76%) for chemigation or fertigation. If CU data is not available, distribution patterns and spacing requirements shall be in keeping with the appropriate criteria of this standard.

**Nutrient and Pest Management.** Apply chemicals and liquid manure in accordance with the appropriate NRCS Conservation Practice Standards: 590, Nutrient Management; 595, Pest Management; 633, Waste Utilization; and, 634, Manure Transfer. Chemical or nutrient application amounts shall not exceed these standards.

NEH, Part 623, Chapter 2 contains guidance for chemigation with sprinkler systems.

**Additional Criteria for Leaching**

**Application Rate and Depth.** Application rates shall meet the levels specified in General Criteria. Determine the depth as defined in NRCS, NEH, Part 623, Chapter 2, Irrigation Water Requirements.

**Management or Reclamation Plan.** Write a plan to conform to NRCS Conservation Practice Standard 610, Salinity and Sodic Soil Management.

**Additional Criteria for Reducing Particulate Matter Emissions to Improve Air Quality**

These criteria pertains to sprinkler systems used to improve air quality by controlling dust emissions from confined animal pen areas and other critical areas such as unpaved roads, staging areas, and equipment storage yards.

Installation of fixed solid set sprinklers or periodic move sprinkler systems for dust control shall conform to the criteria stated above, unless described by criteria in this section. The installation and operation of sprinkler systems for dust control on confined animal pen areas shall provide coverage on pen areas occupied by livestock, except for feed bunk aprons. The quality of water applied shall be pathogen free and suitable for animal consumption.

**Capacity and Application Rate.** The dust-control sprinkler system shall have sufficient capacity and operational flexibility to apply the design application depth within three days. The design application rate shall at least meet the maximum total wet soil evaporation rate.

Open-lot management practices shall include scraping and removal of manure in pens between occupations, and shaping of the holding areas to prevent water ponding or chronic wet areas.

Avoid excess application and sprinkler overlap to minimize runoff, odor, and fly problems.

**Water Amendments.** If appropriate, apply chemicals, labeled for pest control or dust suppression, through the sprinkler systems designed, installed, and operated with appropriate backflow prevention and anti-siphon devices. Follow product labels to protect surface waters and livestock health when applying chemicals through the sprinkler system.

**Distribution Patterns and Spacing.** Select a combination of sprinkler spacing, nozzle size, and operating pressure that provides the design application rate and distribution pattern.

Maximum spacing of sprinklers along laterals shall not be greater than 75 percent, and no closer than 50 percent of wetted diameter listed in manufacturer's performance tables. Spacing between laterals shall comply with the following criteria:

1. For medium pressure nozzles (51-75 psi), the spacing of laterals along the main line shall be no more than 90 percent, and no closer than 70 percent of wetted diameter.
2. For high-pressure nozzles (>75 psi), the maximum distance between two sprinklers on adjacent lateral lines shall not exceed 100% of wetted diameter.
3. If winds affect distribution patterns, equip the system with timer overrides for flexibility to operate during periods of lesser wind, such as late evening and early morning.

**Risers.** Design risers high enough to minimize interference with the distribution pattern. Protect the risers from corrosive soils, equipment damage, and livestock damage. The nozzle height shall not be less than 6 feet above ground surface. Anchor and stabilize all risers.

**System Valves and Controllers.** Due to high application rates inherent with large sprinkler nozzle diameters, an automatic irrigation control system shall be utilized for all nozzles greater than 0.5 inch diameter. The automated valves shall be of a size and quality consistent with standard engineering practice. The operating system shall provide the flexibility to change sprinkling duration by one-minute increments and have a minimum of six start-times per-day to provide for changing weather conditions.

Systems shall be equipped with a rain sensor connected to the control valve network to prevent system operation during rainfall events.

Incorporate manual zone isolation valves to isolate laterals allowing partial system operation for periods of maintenance.

Incorporate a control valve or low-head drainage device in areas of uneven or sloping terrain for each sprinkler, to minimize line drainage to the lowest sprinkler.

## **CONSIDERATIONS**

When planning this practice the following items should be considered, where applicable:

Application rates near the end of a center pivot may exceed soil intake rate. Light, frequent applications can reduce runoff problems, but may increase soil surface evaporation. Use nozzle offsets or booms to reduce application rates.

On low suspended nozzle application systems, row arrangement, nozzle spacing, discharge nozzle type and configuration, and height affect CU. System design and field management should complement each other to yield the highest CU. In general, circular rows for center pivots and straight rows for linear move systems provide higher CU's.

Some factors of non-uniformity tend to average out throughout the season such as different wind direction and travel speed on subsequent irrigations.

Other factors of non-uniformity accumulate during the irrigation season such as, effects on nozzle discharge due to nozzle wear, and pressure; surface water movement, same wind direction, and low CU along field boundaries.

Center pivot corner units or end guns reduce flow available in the circle, lowering the CU.

The positive effects of conservation practices applied to limit surface redistribution of water and runoff may diminish over the irrigation season.

Consider the velocity and timing of prevailing winds when planning a sprinkler system. Design the system to operate in varied time increments to aid in balancing the effects of day and night wind patterns.

Install drop tubes alternately on both sides of the mainline. When used in-crop they should have a flexible joint between the gooseneck pipes and the application device. Consider weighting the drops due to windy conditions.

Management of sprinkler irrigation systems includes utilizing soil water in the root zone, especially during critical crop growth stages.

Deflection of spans on center pivots and linear-move systems affects nozzle heights and is common with a pipe full of water.

Wheel track depth may change during the season and affect nozzle height.

Water distribution is greatly affected by nozzle spacing and height for LPIC and MESA systems. In general, smaller, more closely spaced nozzles will yield a higher uniformity than larger, more widely spaced nozzles.

On center pivot or linear move systems, divert nozzles away from wheel tracks to minimize rutting.

Small changes in pressure affect low-pressure systems (2 to 35 psi.) most. Consider pressure regulators on all low pressure systems where elevation differences, pivot pressure, friction loss, and corner units or end guns will change nozzle discharge and uniformity. Also consider installing a pressure gauge at both ends of the sprinkler system to monitor system pressure.

Consider system effects on the water budget, especially the amount of evapo-transpiration, runoff, infiltration, and deep percolation.

Consider system effects on erosion and soluble substances carried by runoff.

Consider system effects on soil salinity and downstream water quality including subsurface drains.

Some crops are more sensitive to salts applied to plant foliage than to similar water salinity applied by surface irrigation, sub-irrigation, and microirrigation. Information on foliar injury from saline water applied by sprinkler irrigation is contained in NEH, Part 623, Chapter 2.

To reduce odor when applying wastewater, consider timing of irrigation based on prevailing winds. In areas of high visibility, consider irrigating at night. The use of wastewater may reduce the life of the system due to corrosion or abrasion. Flush lines with clean water.

When utilized for dust control, ensure adequate water supplies are available to meet other operating needs.

Irregularly shaped pen areas may be impractical to treat with a sprinkler system. Use other dust-suppression methods.

Open-feedlot management practices that minimize thickness of loose manure may reduce water demands for dust control, as well as, reduce wet areas and ponding that could increase ammonia emissions.

## **PLANS AND SPECIFICATIONS**

Plans and specifications for constructing irrigation sprinkler systems shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

## **OPERATION AND MAINTENANCE**

An operation and maintenance plan must provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide information regarding periodic inspections and prompt repair or replacement of damaged components. The plan, at minimum, shall include provisions to address the following:

- Periodic checks and removal of debris and sediment as necessary from nozzles to assure proper operation.
- Regular testing of pressures and flow rates to assure proper operation.
- Periodic checks of all nozzles and spray heads for proper operation and wear.
- Perform routine inspection, testing, and maintenance of all system components, such as pumps, valves, water meter, and pipes, in accordance with the manufacturer's recommendations.
- Prior to retrofitting any electrically powered irrigation equipment, disconnect electrical service and verify the absence of stray electrical current.
- Irrigation Water Management performed at least annually.